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Effects of Human Disturbances on the Behavior of Wintering Ducks

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Effects of human disturbances on the behavior of wintering ducks

Melissa L. Pease, Robert K. Rose, and Mark J. Butler

Abstract Human activity causes wintering waterfowl to expend energy to avoid humans at a time in their annual cycle when energy conservation is important to survival, migration, and breeding reserves. Understanding the effects of recreational activities on waterfowl is important to managing natural resource areas where migratory birds depend on wetland habitat for resting and feeding. We investigated responses of 7 species of dabbling ducks to 5 different experimental human activities, (a pedestrian, a bicyclist, a truck traveling at 2 different speeds, and an electric passenger tram). Responses of ducks depended on type of disturbance, species, and distance from disturbances. Most birds responded to the treatments. People walking and biking disturbed ducks more than vehicles did. Northern pintail (*Anas acuta*) was the species least sensitive to disturbance, whereas American wigeon (*A. americana*), green-winged teal (*A. crecca*), and gadwall (*A. strepera*) were most sensitive. Ducks were more likely to fly when closer to sources of disturbance. These results will be helpful to managers making decisions about public use that strive to minimize disturbance of dabbling ducks.

Key words *Anas*, Anatidae, behavior, ducks, human disturbance, impoundments, mid-Atlantic region, recreation, waterfowl

Human presence alone can negatively affect wildlife by causing animals to alter behaviors necessary to survival, such as feeding. Because the number of Americans participating in outdoor recreational activities has increased in recent decades, conflicts between humans and wildlife have been steadily increasing (Anderson and Keith 1980, Boyle and Samson 1985). Furthermore, coastal flyways in the continental United States and associated wetland habitats upon which migratory waterbirds depend frequently correspond with areas of largest human development (Purdy et al. 1987). Coastal wetland habitat continues to be lost to human development; therefore, it is increasingly important to minimize the effects of human activity on waterbird behavior in remaining habitat.

Ducks rely in part on stored lipids and nutrients gained while wintering, staging, and migrating to meet the high energetic costs of reproduction. For example, stored lipids may indirectly influence clutch size in ducks by providing the energy hens need to forage for the protein food sources required for egg production (Krapu 1981). Migration between wintering and breeding grounds also imposes high energetic costs on waterfowl. From a resource management perspective, it is important to assess human activities that may adversely affect energy reserves of wintering, staging, and migrating waterfowl, which, in turn, affect nesting success, fecundity, and survival of waterfowl (Ankney and MacInnes 1978, Krapu 1981, Havera et al. 1992).

Many natural resource managers are charged by their administrators with balancing multiple and often conflicting uses, which include resource protection and human recreation. Managers are

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increasingly required to make decisions about types and amounts of public use that should be allowed without degrading an area's value to wildlife. Such decisions often are controversial and challenged by the public. In order for managers to make defensible decisions about recreational uses that minimize impacts on waterfowl, information must be obtained about impacts of various activities and which activities have greater or lesser effects (Pomerantz et al. 1988). Our objective was to determine which human activities are most disturbing to dabbling ducks in the genus *Anas* on their wintering grounds.

Several studies have sought to identify how human activities disturb waterbirds (Burger 1981, Bélanger and Bédard 1989, Havera et al. 1992, Klein et al. 1995), but few with the exception of Klein (1993) have used controlled experimental disturbances as we have done in this study.

Study area

The work was conducted on the barrier-spit section of Back Bay National Wildlife Refuge (BBNWR), located along the Atlantic Flyway in the southeast corner of Virginia in the City of Virginia Beach (Figure 1). Like many National Wildlife Refuges along the eastern seaboard, BBNWR was near a large metropolitan area and consequently received heavy public use (Burger 1981, Purdy et al. 1987). A man-made dune system prevented saltwater from entering the 356.3-ha freshwater impoundment system and the freshwater ecosystem of Back Bay (United States Department of the Interior [USDI] 1996). Historically, Back Bay was known for its large concentrations of overwintering waterfowl, which declined partly due to market and sport hunting and, more recently, to changes in water quality that reduced the abundance of submerged aquatic vegetation, important foods for dabbling ducks.

Observation blinds for the study were located in the impoundment system, which was intensively managed in part by water-level manipulation to provide feeding habitat for migratory and overwin-

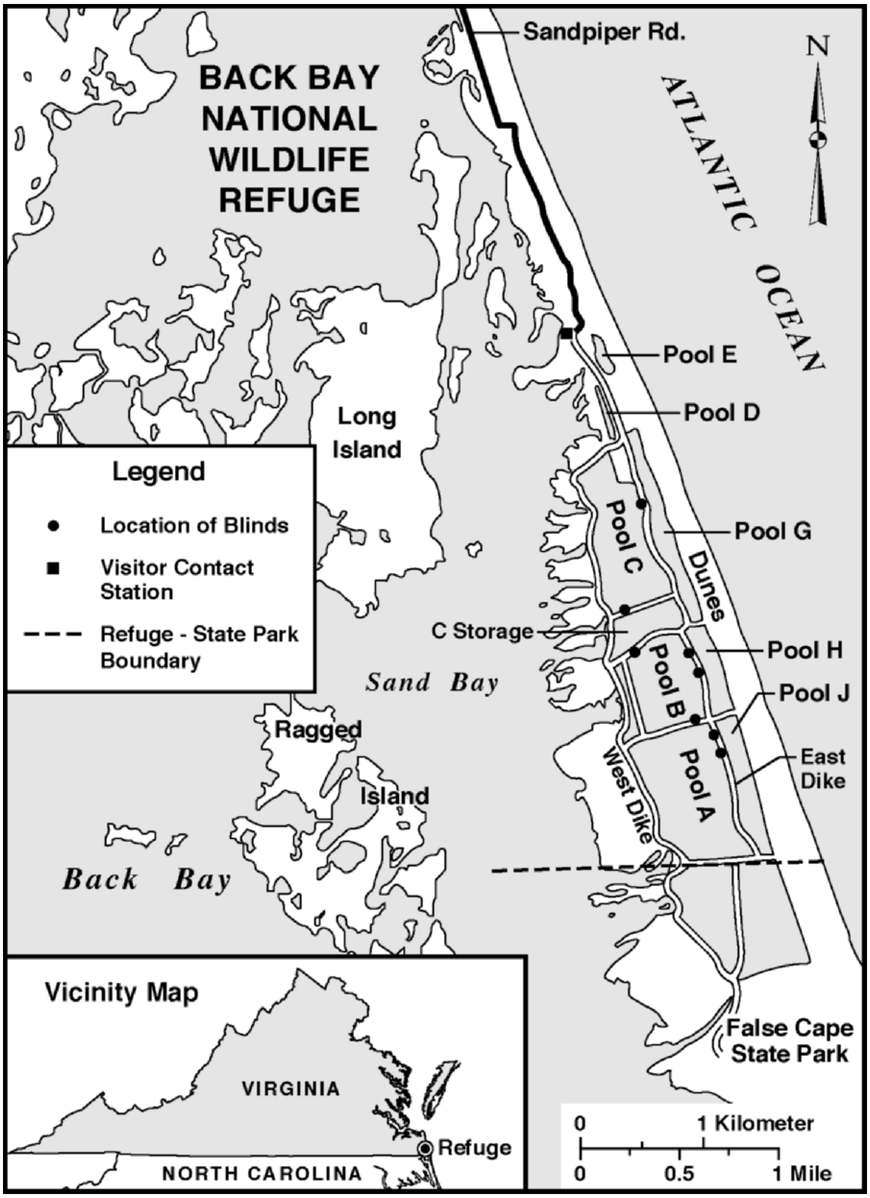

Figure 1. Study area: barrier-spit portion of Back Bay National Wildlife Refuge, Virginia Beach, Virginia, 1998–2000.

tering waterbirds. Dominant species of submerged aquatic vegetation include pondweeds (*Potamogeton* spp.), widgeon-grass (*Ruppia maritima*), water-milfoils (*Myriophyllum* spp.), and coontail (*Ceratophyllum demersum*). The dominant, emergent wetland-associated plants include spike-rushes (*Eleocharis* sp.), bulrushes (*Scirpus* sp.), and water-hyssop (*Bacopa monnieri*). Fragments of maritime forest lay adjacent to the impoundments and on sand mounds within the impoundments.

Two main dikes, called the east and west dikes, were positioned north–south, with individual impoundments being formed by "cross dikes" positioned east–west (Figure 1). The east and west dikes were the only improved surfaces (gravel roads) by which visitors and employees of the Commonwealth of Virginia could gain access to False Cape State Park (FCSP), located south of the refuge. The barrier spit not only contained the highest-quality habitat for waterfowl on the refuge but also sustained the highest public use, creating a conflict between wildlife habitat management and public use objectives.

Methods

The primary researcher (MLP) conducted observations in winter months from 8 November–20 February 1998–1999 and from 1 November–15 February 1999–2000. Five randomly applied experimental treatments simulated the most common human activities on the dike roads, and responses were recorded for the most common dabbling ducks (American black duck [*Anas rubripes*], gadwall [*A. strepera*], mallard [*A. platyrhynchos*], northern pintail [*A. acuta*], American wigeon [*A. Americana*], northern shoveler [*A. clypeata*], and green-winged teal [*A. crecca*]). Volunteers in our study performed standardized disturbances, allowing the primary researcher to make detailed observations (from a blind). Because we observed ducks for approximately 30 minutes before each disturbance event, any change in behavior was easily discernible.

We scheduled 1 treatment every half-hour beginning on the quarter-hour closest to official sunrise and ending no later than 1030, so we could conduct up to 6 treatments in 1 morning. We randomly determined the order and type of treatments, plus a control. We recorded the response of an individual bird, the experimental unit, during each disturbance event. We scheduled work every other day to minimize disturbance to wintering birds. We cancelled study days during times of heavy fog, high winds, and frozen water, and ended them early when the refuge staff conducted biweekly aerial surveys or when there were insufficient numbers of ducks in the study area.

The researcher's blind at the edge of a study area.

Experimental human activities

We conducted all treatments at a constant speed along the dike roads except for the control. The treatments were as follows:

1. *Control.* No human activity was performed and the observation period lasted 2 minutes, based on the average time it took for the treatments to be conducted.
2. *Tram.* A white electric tram traveled at its maximum speed of ca. 21 km/hour. This tram, used to move visitors through the impoundment system during nonwinter months to FCSP, had a driver's cart and 2 passenger carts. Because weighted carts bounce less on the

gravel roads and may create less noise than empty carts, 1 cart was weighted with approximately 340 kg of gravel-filled bags to simulate the weight of passengers.

3. *Slow truck*. A white 1994 Chevrolet Cheyenne™ (General Motors, Pontiac, Mich.) with dual rear tires and an 8-cylinder diesel-powered engine traveled at ca. 21 km/hour. This speed, the same speed as the tram, allowed a direct comparison between the slow truck and the tram.
4. *Fast truck*. The same truck used in the slow-truck treatment traveled at 48 km/hour.
5. *Bicyclist*. One person biked at ca. 11.38 km/hour on a dark blue or black bicycle.
6. *Pedestrian*. One person walked at ca. 3.17 km/hour.

Volunteers wore clothes of neutral colors or earth tones while conducting treatments. For coordination and standardization purposes, volunteers attended an orientation session at the beginning of each season, received protocol instructions via phone the night before each study morning, and received written directions each study morning.

Observations of duck responses

Study areas were open areas of shallow water with minimal emergent vegetation. The primary researcher made observations of duck responses with Pentax® 8 × 42 binoculars (Pentax Corporation, Tokyo, Japan) from 1.22 × 1.22 × 1.68-m camouflage-painted plywood blinds. We placed 4 blinds, each with 4 sides and a roof to conceal the researcher from birds in all directions, along the dike roads at the edges of the impoundments. We moved blinds during the season as concentrations

Northern shovelers within 25m of the researcher's blind.

The tram transporting visitors through Back Bay National Wildlife Refuge along the East Dike.

of waterfowl shifted in reaction to managed changes in water levels of the pools.

The primary researcher entered the blind before sunrise at least 30 minutes before the first scheduled treatment. She first drove to within ca. 300 m of the blind, and the remaining approach was made through concealing vegetation to minimize disturbance. This method of approach did not cause ducks to fly from the study areas.

We chose individual ducks to examine responses of different species at different distances and in different positions in the flock. To reduce potential bias, the researcher targeted an individual bird a few minutes before the treatment (if an individual bird was not chosen until the treatment was initiated, one might inadvertently get an indication of the bird's probable response). We made efforts to avoid observing the same individuals repeatedly, though this would be unlikely given the thousands of ducks present at the refuge and the movement of flocks southward during times of unusually cold weather. In the rare event that a volunteer did not follow protocol or an external stimulus corresponded with the timing of a treatment (e.g., plane or predatory bird flying overhead), we did not include the observation in the analysis, to ensure that the reactions of birds were in response to treatments. Hours of observation totaled 191, although this number was not relevant to the statistical analysis of this study.

We assumed that the following responses were graded indicators of the level of disturbance imposed on a bird: 1) no observable response or change in behavior, the least-disturbed state; 2) became alert: the bird raised its head or feeding was interrupted, but it did not move away from the source of human activity; 3) swam away: the bird swam any distance away from source of human activity; and 4) flew away: the bird flew any distance away from source of human activity.

Distance from source of disturbance

The primary researcher recorded distance from the source of disturbance (dike road) to the bird's pretreatment location. Distance categories were 0–50 m, 51–100 m, 101–150 m, 151–200 m, 201–250 m, and 251–300 m. To improve accuracy of the distance estimates, we placed stakes made of natural wood and white polyvinyl chloride (PVC) pipes in the impoundments at 50-m intervals measured from the edge of the road. Other white PVC pipes had been placed in the impoundments by refuge staff many years before this study, so there was little reason to believe they affected bird behavior.

Statistical analysis

We used a multidimensional log-linear (contingency table) analysis to test the null hypothesis that frequencies of bird responses (4 levels) were independent of disturbance treatments (6 levels), species (7 levels), and distances from the source of disturbance (5 levels) at $\alpha=0.05$. The 201–150-m and the 251–300-m categories were combined due to small sample sizes. The 4-way and 3-way interactions were not significant. The *P*-value was adjusted to $\alpha=0.013$ for the 2-way interactions to account for multiple tests. The 2-way analysis of duck responses as a function of disturbance treatments was subdivided (Zar 1999) to find differences among treatments at $\alpha=0.006$.

Because we chose treatments randomly, their sample sizes are similar: 1) control, $n=62$; 2) tram, $n=59$; 3) slow truck, $n=73$; 4) fast truck, $n=57$; 5) bicyclist, $n=62$; 6) pedestrian, $n=69$. Sample sizes for the different species and distance categories were not equal. It is typical to have unequal sample sizes in contingency table analyses and this has no bearing on the results.

Results

Responses of ducks depended on the type of human disturbance (likelihood ratio $\chi^2=222.68$, df $=15$, $P<0.001$, $n=382$) at $\alpha=0.013$ (Figure 2). Pedestrians and bicyclists caused the highest proportions of ducks to fly (Figure 2). There were no differences among the vehicular treatments in the number of ducks that flew, and no difference

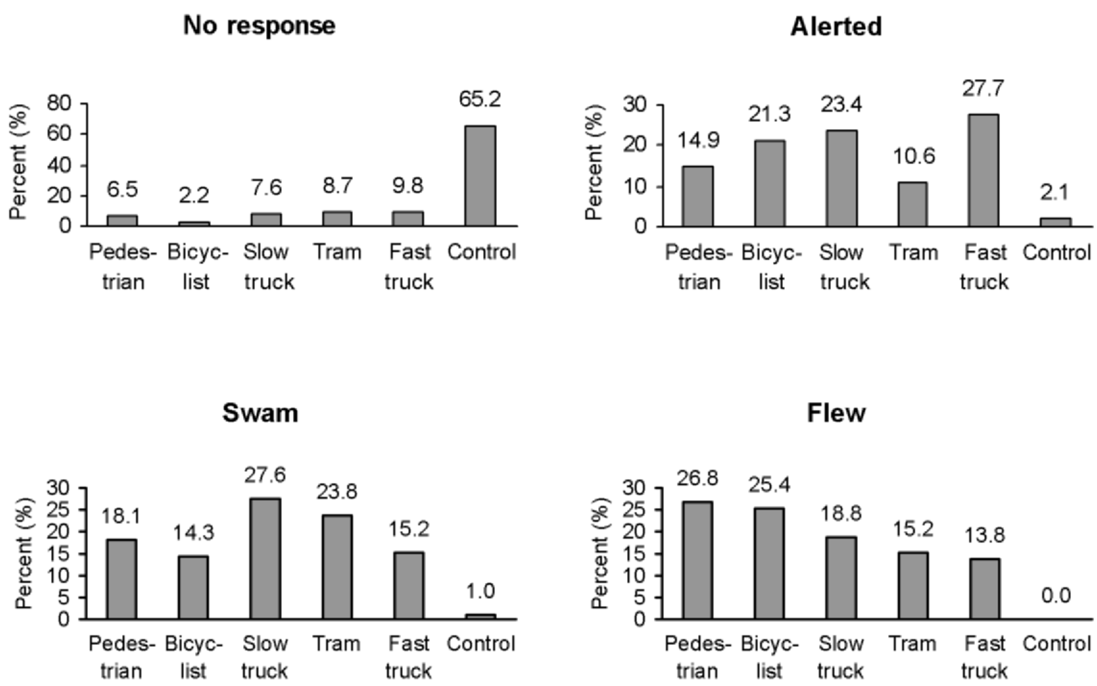

Figure 2. Proportions of duck responses exhibited for each human disturbance; includes all 7 species observed. From χ^2 analysis of response as a function of disturbance treatment, likelihood ratio $\chi^2 = 222.68$, df = 15, $P < 0.001$, $n = 382$, Back Bay National Wildlife Refuge, Virginia Beach, Virginia, 1998–2000.

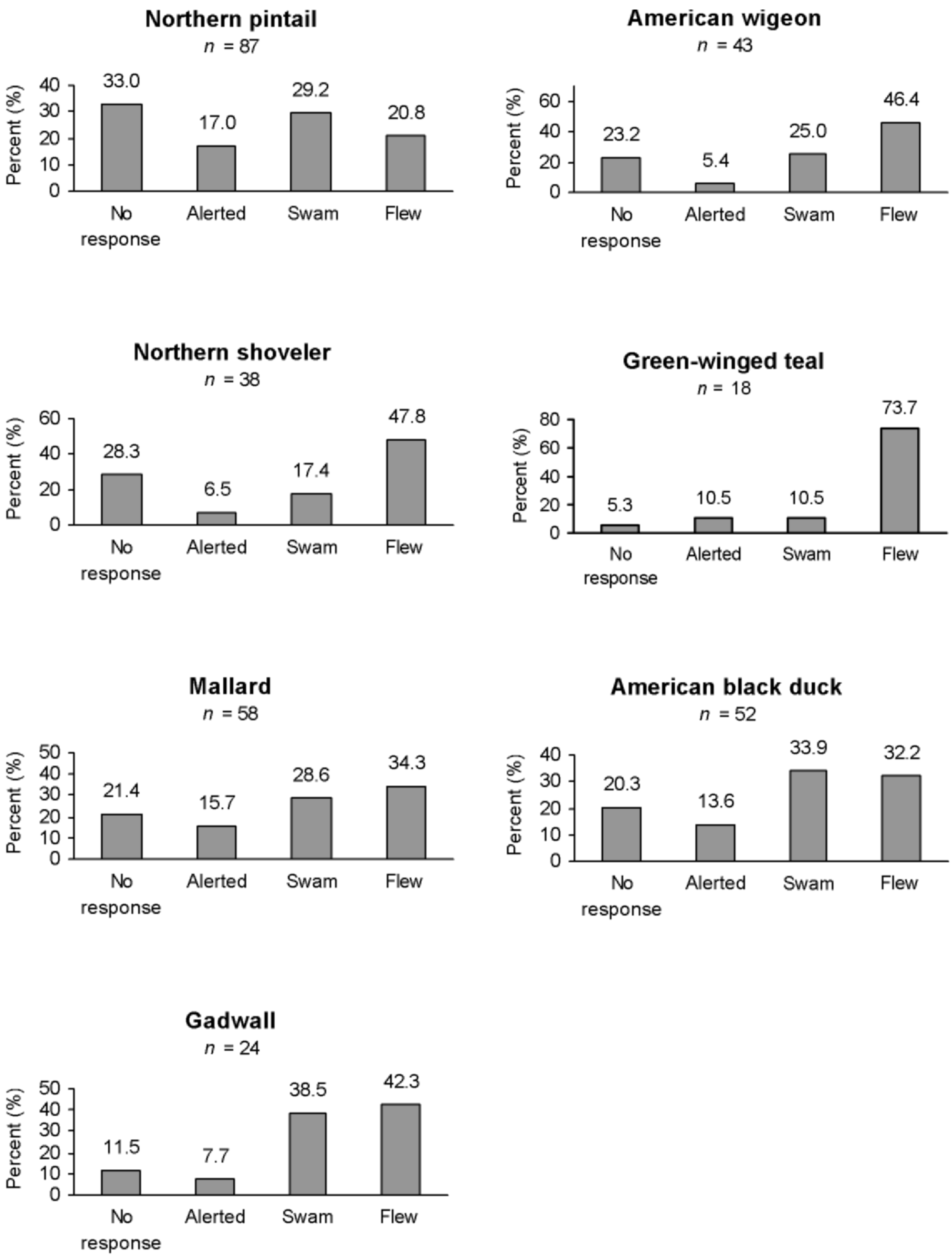

Figure 3. Proportions of duck responses within each species; includes all forms of human disturbance tested. From χ^2 analysis of response as a function of species, likelihood ratio $\chi^2 = 41.75$, df = 18, $P < 0.001$, $n = 382$, Back Bay National Wildlife Refuge, Virginia Beach, Virginia, 1998–2000.

among nonvehicular treatments (pedestrians and bicyclists) in the number of ducks that flew. However, there was a difference between vehicular and nonvehicular treatments in the number of ducks that flew (likelihood ratio $\chi^2=12.68$, df=1, $P<0.001$, $n=320$) at $\alpha=0.006$ (Figure 2). Ninety

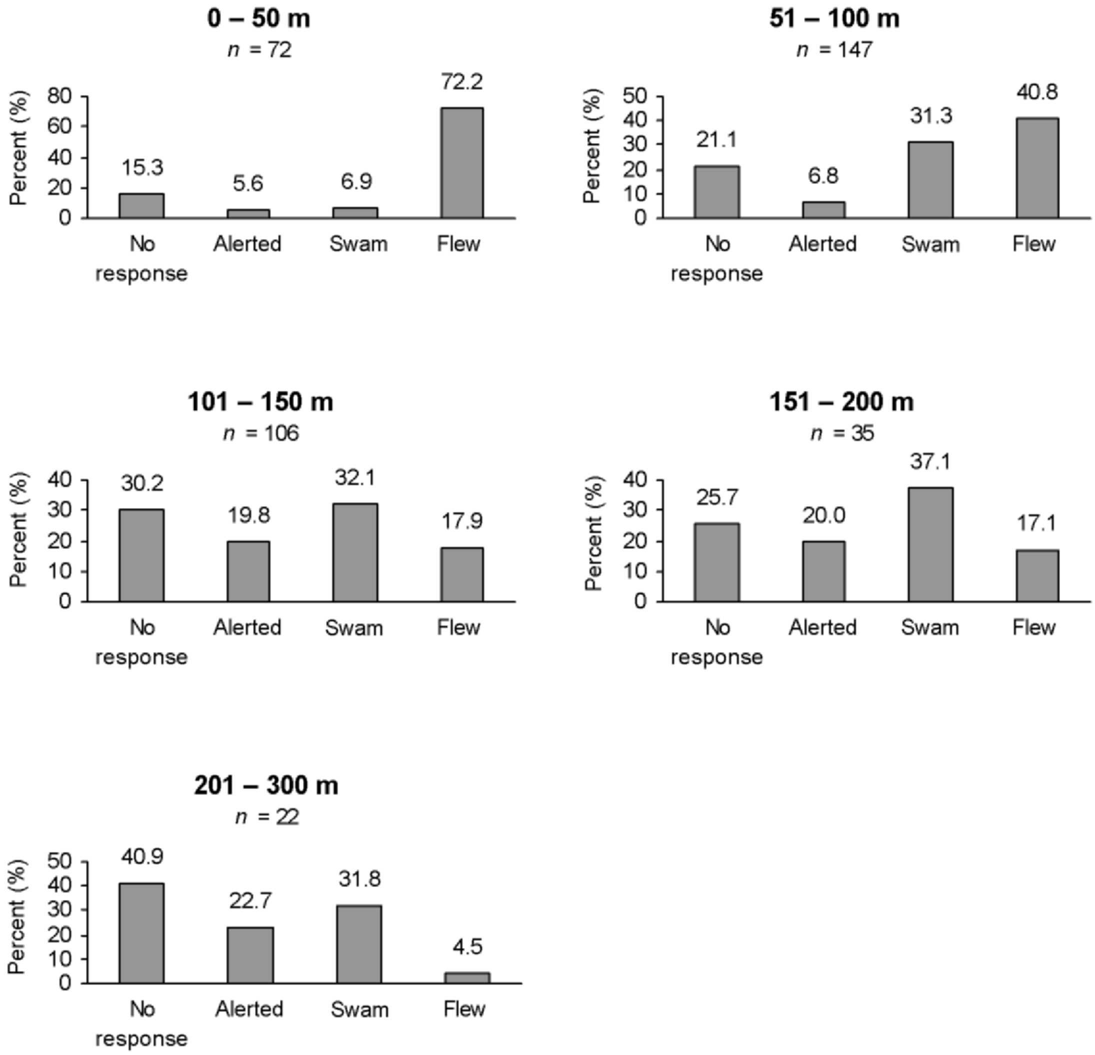

Figure 4. Proportions of duck responses exhibited at each distance; includes all 7 species observed. From χ^2 analysis of response as a function of distance the ducks were from the source of disturbance, likelihood ratio χ^2 = 87.18, df = 12, $P < 0.001$, n = 382, Back Bay National Wildlife Refuge, Virginia Beach, Virginia, 1998–2000.

percent of the birds showed an observable response (alerted, swam, or flew) to the human activities, of which 43.1% flew. All but 2 responses to the control treatments were "no response."

Responses of ducks also depended on species (likelihood ratio $\chi^2 = 41.75$, df $= 18$, $P < 0.001$, $n = 382$) at $\alpha = 0.013$ (Figure 3). Northern pintail had the lowest proportion of flight response and, conversely, demonstrated the highest proportion of "no response." American wigeon, northern shoveler, green-winged teal, and gadwall demonstrated high proportions of flight responses. Conversely, green-winged teal and gadwall demonstrated the lowest proportions of "no response" (Figure 3).

Responses of ducks depended on distances the ducks were located from the dike road (likelihood ratio $\chi^2 = 87.18$, df $= 12$, $P < 0.001$, $n = 382$) at $\alpha = 0.013$ (Figure 4). The proportion of ducks that flew was greatest in the 0–50-m and 51–100-m categories (Figure 4). We observed a predictable graded response with respect to distance as ducks nearer the source of disturbance showed higher proportions of responses and higher levels of flight responses than ducks located farther away: 1) for the 0–50-m distance category, 84.7% of the birds responded (alerted, swam, or flew); 2) 51–100-m, 78.9% responded; 3) 101–150-m, 69.8% responded; 4) 151–200-m, 74.2% responded; and 5) 201–300-m, 59.0% responded. Conversely, the incidence of "no response" increased with distance (Figure 4).

Discussion

Because people walking and biking caused more ducks to fly, we judged these activities to be more disturbing than vehicles to the 7 species of dabbling ducks studied. Flight response is of greatest interest of those studied because it requires the highest energetic output for birds. These results were consistent with Klein's (1993) conclusion that "out-of-vehicle-activity" (people getting out of vehicles to observe wildlife) was more disturbing than vehicular traffic. We suspected the electric tram would be less disturbing to waterfowl than other vehicles because it is considered inherently quieter than a combustion engine; however, we found the tram to be no less disturbing than a diesel truck traveling the same speed.

Because the 3-way interaction between the response variables, the independent variables, and species was not significant, the analysis does not allow individual species to be discernible in the 2-way analysis of duck responses as a function of disturbance treatments (Figure 2). Although we treated all species together in this case, the results indicating which human activities were more or less disturbing to ducks in the genus *Anas* are valuable because the ducks are closely related. Klein et al. (1995) found dabbling ducks, as a group, to be sensitive to lower rates of vehicular traffic than some other water birds.

A person walking was highly disturbing to ducks in this study, making it unclear how birdwatchers could be minimally disturbing to birds, as reported by Burger (1981). Burger (1981) reported that birdwatchers walking slowly as they search for birds and people digging clams in shallow water usually did not cause birds to flush. People walking in this study were moving at a steady pace, unlike birdwatchers whose pace typically involves periods of standing still.

It is important to understand differences among species when evaluating impacts of recreational use (Vaske et al. 1983). We considered proportions of flight response and "no response," indicating sensitivity and tolerance respectively, in judging relative sensitivity between species. Northern pintail clearly was the least-sensitive species. American wigeon, green-winged teal, and gadwall were the most sensitive. Although it may appear that northern shovelers were relatively sensitive because of their high incidence of flight response, this species flew more because they were more often located closest to the source of disturbance (Pease 2001). Another indication that they are not among the most sensitive species is their high proportion of "no response" indicating relative tolerance to disturbance (Figure 3).

Birds were more severely affected by human disturbance the closer they were to the road, the source of disturbance. Although lower percentages of birds flew the farther they were from the road, they responded in other ways that included swimming and alerting. Very few birds showed no response to human activity.

It was not possible to determine the extent to which ducks were indirectly responding to each other, a product of the realistic field-based design of this study. We speculate the results are conservative to some degree because as each morning progressed, a more and more tolerant group of ducks remained. This resulted from observations we made of the most sensitive birds leaving the study area altogether due to earlier treatments and few new birds moving into study areas.

Management implications

As in most refuges managed by the United States Fish and Wildlife Service, providing habitat for migratory waterbirds is a primary objective at BBNWR. Therefore, management activities and resources of the refuge are focused on the impoundment system, which is formed by dikes that also function as access roads to FCSP. Finding a solution to the dilemma of ensuring adequate access to the state park while not compromising the primary objective of the refuge was the subject of a Final Environmental Assessment (FEA) dated September 1996 (USDI 1996). Part of the solution to facilitate visitation to the park was the tram system, which is why the tram was of interest in this study. Our research was initiated as a result of the FEA process.

The essence of the refuge's solution is spatial and seasonal control of public access (USDI 1996). At specific times of the year, people are routed away from areas where migratory bird concentrations are highest, and from 1 November–31 March the impoundment system is closed to the public altogether. Our study emphasizes the need for continued seasonal closure of the impoundment system in order to protect overwintering dabbling ducks from disturbance at a time when fat deposition and energy conservation are important. It is important that human disturbance levels on the dike roads do not limit the use of the impoundment system by the birds for which it was created. Although the Back Bay watershed currently is rural in nature, development is steadily encroaching (United States Fish and Wildlife Service 1993). As this trend continues, public-use pressures are likely to increase at BBNWR.

A tram or bus system is an access method that may reduce the impact on birds and other wildlife while allowing the public to see wildlife in natural areas. Trams or buses not only reduce the rate of disturbances but also potentially eliminate the most disruptive disturbances: humans walking or biking (Pease 2001) and humans approaching birds (Klein 1993). A bus or tram system enhances wildlife viewing, especially with knowledgeable drivers providing environmental interpretation. Also, many people watching together increases the chance of spotting wildlife and more wildlife may be present due to lower disturbance rates.

The adverse effects of human disturbance are compounded by other anthropogenic stresses on bird populations, such as degradation of wetland habitat through development, pollution, and invasive species. Impacts of human disturbance also are likely compounded for wintering and migrating birds during times of unusual weather patterns or storm events that can significantly alter food supplies (Owens 1977). Because waterfowl face continued loss of habitat, the need to minimize human recreational impacts in remaining habitat is imperative.

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